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13. ABSTRACT (Maximum 200 words)

Our overall objective is to demonstrate powerful new signal processing functionalities for ultrafast optical signals, with an emphasis on proof-of-concept experiments of new space-time (parallel-serial) optical processing methods. A key goal is to develop efficient methods for parallel-serial conversion of ultrafast optical signals, with potential application as an enabler for subsystems performing digital logic operations on ultrafast optical bit streams, especially encryption and temporal pattern matching operations. In particular, we have focused on research on subsystems for: (1) space-to-time conversion (or parallel-to-serial conversion) for generating ultrafast optical output pulse sequences corresponding to parallel (electronic) input data, and (2) time-to-space conversion (or serial-to-parallel conversion) for demultiplexing ultrafast time-domain optical data. In addition, we also obtained significant new results by applying our space-to-time converter for millimeter-wave arbitrary waveform generation. These results, not anticipated at the time of our proposal, open opportunities for generation of user defined, broadband electromagnetic signals at frequencies more than an order beyond the fastest commercial electronic arbitrary waveform generation instrumentation.

14. SUBJECT TERMS
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4. Problem Statement

Our overall objective is to demonstrate powerful new signal processing functionalities for ultrafast optical signals, with an emphasis on proof-of-concept experiments of new space-time (parallel-serial) optical processing methods. A key goal is to develop efficient methods for parallel-serial conversion of ultrafast optical signals, with potential application as an enabler for subsystems performing digital logic operations on ultrafast optical bit streams, especially encryption and temporal pattern matching operations. In particular, we have focused on research on subsystems for: (1) space-to-time conversion (or parallel-to-serial conversion) for generating ultrafast optical output pulse sequences corresponding to parallel (electronic) input data, and (2) time-to-space conversion (or serial-to-parallel conversion) for demultiplexing ultrafast time-domain optical data. In addition, we also obtained significant new results by applying our space-to-time converter for millimeter-wave arbitrary waveform generation. These results, not anticipated at the time of our proposal, open opportunities for generation of user defined, broadband electromagnetic signals at frequencies more than an order beyond the fastest commercial electronic arbitrary waveform generation instrumentation.

5. Summary of Results

5(a) Direct space-to-time pulse shaper

In previous work we demonstrated first femtosecond operation of a direct space-to-time (DST) pulse shaper, in which the output ultrafast optical waveform or pulse sequence is a direct temporal replica of a spatial masking pattern. This is in contrast to the widely used Fourier transform (FT) pulse shaper with a Fourier transform relationship between the masking pattern and the output temporal waveform. The direct space-to-time scaling in the DST pulse shaper is advantageous for ultrafast parallel to serial conversion applications. Our original experiments had been performed using a Ti:sapphire femtosecond laser at 850 nm wavelength 850 nm and 80 MHz repetition rate. In our research under this contract, we were able to construct the first DST pulse shaper that works in the 1.55 micron lightwave band. In addition to the shift of wavelength into this important wavelength band, other innovations include:

- Use of a diffractive optical element (DOE) to perform the spatial patterning needed at the input of the DST shaper. The DOE eliminates loss associated with the use of amplitude mask for spatial patterning, while significantly aiding in our goal of obtaining equal pulse intensities for different pulses in the generated pulse sequences.

- Demonstration of pulse sequence generation over greater than a 100 psec temporal aperture, compared to ~40 psec in our previous work.

- Realization of fiber input and output

- Demonstration of the first DST pulse shaper with low polarization–dependent loss

In our original work using a Ti:Sapphire laser, and in our work using a modelocked fiber laser performed during the initial period of this contract, experiments were performed at low repetition rates (below 100 MHz). This meant that the generated pulse sequences were isolated from each other in time (very low duty cycle). Since then, we succeeded in building up an ultrashort pulse fiber laser providing pulses at a much higher repetition rate (10 GHz). By using this new fiber laser together with our direct space-to-time pulse shaper, we were able to generate continuously periodic, modulated optical pulse sequences with 100% duty cycle. The key point is that the 100 ps pulse repetition period from the laser

can be matched to the time aperture (also ~100 ps) of the pulse sequence generated by the pulse shaper. These results are a substantial step forward towards practical application.

5(b) Integrated optics pulse sequence generation

We have also been working on the possibility of implementing a DST pulse shaper (space-to-time converter) using an integrated-optic arrayed-waveguide-grating (AWG) structure. AWGs have received considerable interest for WDM optical networks, but prior to our work they have seen little attention for time-domain applications. The DST pulse shaper may be considered a bulk optics version of the AWG, and therefore our results provide guidance concerning the proper AWG design for time-domain pulse shaping applications. The importance for our time-domain applications is that the AWG is a compact and robust integrated technology. In previous experiments we showed that AWGs could be made to function as pulse train generators, leading to generation of bursts of 10-20 pulses with peak rates on the order of 1 THz. In our research under this contract, we achieved a number of new results, summarized in the following list. Much of this work was performed in collaboration with NTT Electronics Laboratories (NEL), which provides state-of-the-art fabrication capabilities for this technology.

- We demonstrated AWGs with a modified design, in which loss engineering was successfully utilized in order to equalize the intensities of different pulses in the output sequence. This is an improvement over the original experiments, in which the pulse intensities varied under a Gaussian envelope.

- We performed new experiments using the AWGs in a novel double-pass geometry. This provides new functionalities, including the ability to combine several different output pulse sequences into one much longer output sequence with low loss.

- We initiated studies on the use of "excitation engineering" as an alternate way to control the intensity profile of the output sequence, but without the loss inherent in loss engineering. In this scheme the areas of the input sections of the different waveguides in the waveguide array are varied in order to vary the strength with which different guides are excited. During the research under this contract, we performed preliminary measurements with a 1x16 integrated splitter based on excitation engineering.

- We tested an additional modified structure, in which the waveguide array is modified to provide direct optical access. This allows external control of the light coupled into each of the waveguides, which means that data can now be programmed onto the generated optical pulse sequence. We have confirmed this capability experimentally.

5(c) Time-to-space conversion

In our time-to-space converter work under this contract, we constructed and demonstrated the first time-to-space converter working in the 1.55 micron lightwave communications band. This is in contrast to our earlier experiments which were performed around 850 nm. The time-to-space converter is an approach allowing conversion of an ultrafast serial optical waveform or data stream into a slower parallel optical signal. These time-to-space converters are based on an approach termed spectral nonlinear optics. As in any nonlinear optical approach, the sensitivity and the nonlinear optical conversion efficiency are critical for practical implementation in demanding applications, such as high rate communications. We have optimized the nonlinear optical conversion efficiency of a time-to-space conversion apparatus operating in the lightwave band and confirmed that the measured efficiency closely

matches the theoretical prediction. We have demonstrated that our efficiency is sufficient to allow direct real-time detection of the time-to-space signal with no signal averaging and with excellent signal-to-noise ratio at the 80 MHz repetition rate of our laser. We also performed further experiments in which different ultrafast optical data packets spaced by less than two nanoseconds are independently converted into spatial (parallel) signals, again with excellent signal-to-noise. This goes well beyond ultrafast pulse characterization techniques such as FROG, which generally require signal averaging and iterative retrieval techniques. Finally, we performed a careful system level analysis of the time-to-space converter, which can be used to estimate the power requirements that will needed to scale to operation at rates appropriate for real-time processing of ultrahigh-speed optical data stream at rates of 100 Gb/s and beyond. Our analysis indicates that in order to fully reach this goal, further increases in conversion efficiency are needed, which may be accomplished, e.g., by using planar waveguide nonlinear optical devices.

5(d) General serial-parallel pulse processing via smart pixel optoelectronic arrays

In addition to time-to-space and space-to-time conversion, one of our goals in this proposal was to couple such time-space (serial-parallel) conversion systems to an optoelectronic smart pixel array. The optoelectronic array was intended to take of advantage of electronic processing to implement digital operations, such as optical header recognition and encryption, in a parallel electronic format that could be interfaced with ultrafast optical signals through the serial-parallel conversion subsystems. A smart pixel chip for this purpose was designed several years ago, and fabricated in an experimental foundry process coordinated by Bell Labs under the auspices of the ARPA Consortium for Optical and Optoelectronic Technologies for Computing (CO-OP) program. As part of our research under this contract, we put extensive effort into testing our smart pixel chips, with the aim of demonstrating optical header recognition in conjunction with the time-to-space converter. Unfortunately, our testing revealed critical problems with the array operation, which we believe were likely caused by problems during the fabrication. Based on these problems, we were unable to demonstrate operation of the full processing system including smart pixel processing. However, based on our results with time-to-space converters, we believe that further progress is indeed possible, provided that there is access to properly functioning smart pixel arrays.

5(e) Radio-frequency arbitrary electrical waveform generation

We have exploited our direct space-to-time optical pulse shaping technology in conjunction with a fast (60 GHz bandwidth) optical-to-electronic converter for experiments on generation of burst arbitrary millimeter wave electrical signals. In this way, we leveraged our prowess in optical pulse shaping in order to realize new capabilities for cycle-by-cycle synthesis of wideband electromagnetic waveforms at frequencies in the millimeter-wave regime. These results, not anticipated at the time of our proposal, open opportunities for generation of user defined, broadband electromagnetic signals at frequencies more than an order beyond the fastest commercial electronic arbitrary waveform generation instrumentation. Examples that we have demonstrated include generation of burst waveforms at nearly 50 GHz center frequency with abrupt phase shifts at user designated times, or waveforms with abrupt frequency shifts demonstrating an octave in frequency coverage. The first round of experiments were performed at low repetition rates (below 50 MHz), resulting in generation of isolated burst arbitrary electrical waveforms. Subsequently, we took advantage of our new 10 GHz modelocked laser capability to repeat our arbitrary millimeter wave generation experiments at much higher repetition rates. This results in the first cycle-by-cylce generation of continuous, periodic, ultrawideband signals in the millimeter-wave regime. These experiments are the first of their kind, and may open new opportunities for electronic countermeasures,

pulsed radar, and ultrawideband (UWB) wireless communications at millimeter wave frequencies. In order to pursue such opportunities, we have written a new proposal to ARO entitled "Photonic Synthesis and Processing of Ultrabroadband Radio-Frequency Waveforms," which has been funded under contract DAAD19-03-1-0275. This work has already led to a number of conference presentations, including several invited talks (2002 IEEE LEOS Annual Meeting, 2003 OSA Ultrafast Electronics and Optoelectronics Conference, 2003 IEEE LEOS Annual Meeting).

6. Publications

6(a) Papers published in peer-reviewed journals

"Femtosecond Direct Space-to-Time Pulse Shaping," D. E. Leaird and A. M. Weiner, IEEE Journal of Quantum Electronics **37**, 494-504 (2001).

"Generation of High Repetition Rate WDM Pulse Trains from an Arrayed-Waveguide Grating," D. E. Leaird, S. Shen, A.M. Weiner, A. Sugita, S. Kamei, M. Ishii, and K. Okamoto, IEEE Photonics Technology Letters **13**, 221-223 (2001).

"High Repetition Rate Femtosecond WDM Pulse Generation using Direct Space-to-Time Pulse Shapers and Arrayed Waveguide Gratings," D. E. Leaird, A. M. Weiner, S. Shen, A. Sugita, S. Kamei, M. Ishii, and K. Okamoto, Optical and Quantum Electronics **33**, 811-826 (2001).

"Generation of flat-topped 500-GHz pulse bursts using loss engineered arrayed waveguide Gratings," D. E. Leaird, A. M. Weiner, S. Kamei, M. Ishii, A. Sugita, and K. Okamoto, IEEE Photonics Technology Letters, **14**, 816-818 (2002).

"Millimeter-wave arbitrary waveform generation with a direct space-to-time pulse shaper," J. D. McKinney, D. E. Leaird, and A. M. Weiner, Optics Letters, **27**, 1345-1347 (2002).

"Double-Passed Arrayed Waveguide Grating for 500 GHz Pulse Burst Generation," D. E. Leaird, A. M. Weiner, S. Kamei, M. Ishii, A. Sugita, and K. Okamoto, IEEE Photonics Technology Letters, **14**, 1451-1453 (2002).

"Photonically assisted generation of continuous arbitrary millemetre electromagnetic waveforms," J. D. McKinney, D. S. Seo, and A. M. Weiner, Electronics Letters, **39**, 309-311 (2003).

"Continuous 500 GHz pulse train generation by repetition rate multiplication using arrayed waveguide grating," D.S. Seo, D.E. Leaird, A.M. Weiner, S. Kamei, M. Ishii, A. Sugita, and K. Okamoto, Electronics Letters **39**, 1138-1140 (2003).

"Generalized grating equation for virtually-imaged phase-array (VIPA) spectral dispersers," A. Vega, C. Lin, and A. M. Weiner, Applied Optics **42**, 4152-5155 (2003).

"Direct space-to-time pulse shaping at 1.5μm," J. D. McKinney, D. S. Seo, and A. M. Weiner, IEEE Journal of Quantum Electronics **39**, 1635-1644 (2003).

"Photonically assisted generation of arbitrary millimeter-wave and microwave electromagnetic waveforms via direct space-to-time optical pulse shaping," J. D. McKinney, D. S. Seo, D.E. Leaird, and A. M. Weiner, Journal of Lightwave Technology (accepted for publication).

“Real-time detection of femtosecond optical pulse sequences via time-to-space conversion in the lightwave communications band,” J.-H. Chung and A. M. Weiner, Journal of Lightwave Technology (accepted for publication).

6(b) Papers in non-peer-reviewed journals or in conference proceedings presented at meetings and published in conference proceedings

“Ultrafast Optics for Communications and Information Processing,” **[INVITED]** *A. M. Weiner*, IEEE LEOS Annual Meeting, Rio Grande, Puerto Rico, November 13-16, 2000.

“>500 GHz Repetition Rate WDM Pulse Train Generation via Direct Space-to-Time Pulse Shaping - Bulk & Integrated Optics Implementations,” D. E. Leaird, S. Shen, A. M. Weiner, A. Sugita, S. Kamei, M. Ishii, and K. Okamoto, IEEE LEOS Newletter **4**, 3-4 (2001).

“Direct Space-to-Time Pulse Shaper/Arrayed Waveguide Grating Analogy for High Repetition Rate WDM Pulse Train Generation,” *D. E. Leaird*, S. Shen, A. M. Weiner, A. Sugita, H. Yamada, S. Kamei, M. Ishii, and K. Okamoto, Ultrafast Optics and Optoelectronics 2001, Lake Tahoe, NV, January 10-12, 2001.

“1 THz Repetition Rate Multichannel Pulse Train Source Using an Arrayed Waveguide Grating,” *D. E. Leaird*, S. Shen, A. M. Weiner, A. Sugita, S. Kamei, M. Ishii, and K. Okamoto, Optical Fiber Communication Conference, Anaheim, CA, March 17-22, 2001.

“High Repetition Rate Flat-Topped Pulse Trains from an Arrayed Waveguide Grating,” *D. E. Leaird*, S. Shen, A. M. Weiner, A. Sugita, S. Kamei, M. Ishii, and K. Okamoto, Conference on Lasers and Electro-optics, Baltimore, MD, May 6-11, 2001.

“Nonlinear Optical Processing of Femtosecond Waveforms using Second Harmonic Generation,” **[INVITED]** *A.M. Weiner*, OSA Nonlinear Guided Waves and Their Applications Conference, Clearwater, FL, March 25-28, 2001.

“Programmable Femtosecond Pulse Shaping and Processing,” **[INVITED TUTORIAL]** *A.M. Weiner*, Conference on Lasers and Electro-optics, Baltimore, MD, May 6-11, 2001.

“Optical Information Processing and Waveform Shaping with Femtosecond Pulses,” **[INVITED TUTORIAL]** *A.M. Weiner*, Pacific Rim Conference on Lasers and Electro-optics, Chiba, Japan, July 15-19, 2001.

“Loss Engineered Arrayed Waveguide Gratings for Generating Multiple Wavelength Shifted 500 GHz Repetition Rate Flat-Topped Pulse Trains,” *D. E. Leaird*, A. M. Weiner, A. Sugita, S. Kamei, H. Yamada, M. Ishii, and K. Okamoto, IEEE Lasers and Electro-optics Society Annual Meeting, San Diego, CA, Nov. 12-15, 2001.

“Femtosecond optical information processing via Fourier optics,” A. M. Weiner, SPIE’s International technical Group Newsletter, page 5 (August, 2002).

“MM-Wave Arbitrary Waveform Generation Using a Direct Space-to-Time Optical Pulse Shaper,” J. D. McKinney, D. E. Leaird, and A. M. Weiner, *Ultrafast Phenomena XIII*, R. D. Miller, M. M. Murnane, N.

F. Scherer, and A. M. Weiner, eds. (Berlin: Springer, 2002), 205-207; XIII International Conference on Ultrafast Phenomena, Vancouver, Canada, May 13-17, 2002.

"Time-to-Space Conversion of Ultrafast Optical Pulses via Spectral Nonlinear Optics in the Communications Band," J.-H. Chung and A. M. Weiner, *Ultrafast Phenomena XIII*, R. D. Miller, M. M. Murnane, N. F. Scherer, and A. M. Weiner, eds. (Berlin: Springer, 2002), 208-210; XIII International Conference on Ultrafast Phenomena, Vancouver, Canada, May 13-17, 2002.

"Generation of High Repetition Rate Pulse Bursts via Femtosecond Read-out of a Double-Passed Arrayed Waveguide Gratings, *D. E. Leaird*, A. M. Weiner, S. Kamei, M. Ishii, A. Sugita, and K. Okamoto, 2002 Optical Fiber Communications Conference, Anaheim, CA, March 18-20, 2002.

"Femtosecond Optical Information Processing via Femtosecond Fourier Optics," [**PLENARY**] *A. M. Weiner*, International Conference on Optics in Computing, Taipei, Taiwan, April 8-11, 2002.

"Time-to-space conversion of ultrafast optical pulses via spectral nonlinear optics in the 1.5 μm band," *J.-H. Chung* and A. M. Weiner, Conference on Lasers and Electro-optics, Long Beach, CA, May 20-24, 2002.

"1.5 μm Direct Space-to-Time Pulse Shaper Utilizing a Diffractive Optical Element for Pattern Generation," *J. D. McKinney* and A. M. Weiner, Conference on Lasers and Electro-optics, Long Beach, CA, May 20-24, 2002.

"Femtosecond Pulse Sequence Processing Using a Double-Passed Array Waveguide Grating," *D. E. Leaird*, A. M. Weiner, S. Kamei, M. Ishii, A. Sugita, and K. Okamoto, Conference on Lasers and Electro-optics, Long Beach, CA, May 20-24, 2002.

"Very High Speed Pulse Sequence Generation via Femtosecond Read-out of Arrayed Waveguide Gratings," [**INVITED**] *A. M. Weiner*, D. E. Leaird, Vancouver, Canada, July 17-19, 2002.

"Burst Arbitrary Millimeter Waveform Generation via a Direct Space-to-Time Optical Pulse Shaper," *J. D. McKinney*, D. E. Leaird, and A. M. Weiner, 27th International Conference on Infrared and Millimeter Waves, Long Beach, CA, September 22-26, 2002.

"Electromagnetic Arbitrary Waveform Generation via Down-Conversion of Shaped Femtosecond Pulses," [**INVITED**] *A. M. Weiner*, 15th Annual Meeting of the IEEE Lasers and Electro-Optics Society, Glasgow, Scotland, November 10-14, 2002.

"Photonically Assisted Burst and Continuous Arbitrary Millimeter Waveform Generation via a Direct Space-to-Time Pulse Shaping," [**INVITED**] *J. D. McKinney*, D. S. Seo, and A. M. Weiner, Ultrafast Electronics and Optoelectronics, Washington, DC, January 15-16, 2003.

"100 GHz Sequence Generation from a 1.5 μm Direct Space-to-Time Pulse Shaper," *J. D. McKinney*, D. S. Seo, and A. M. Weiner, Ultrafast Electronics and Optoelectronics, Washington, DC, January 15-16, 2003.

"High Repetition Rate Femtosecond Direct Space-to-Time Pulse Shaping Using a Modified Arrayed Waveguide Grating," *D. E. Leaird* and A. M. Weiner, Conference on Lasers and Electro-optics, Baltimore, MD, June 2-6, 2003.

"100 Gb/s Optical Word Generation Using a 1.5 um Direct Space-to-Time Pulse Shaper," *J. D. McKinney* and A. M. Weiner, Conference on Lasers and Electro-optics, Baltimore, MD, June 2-6, 2003.

"Photonically-assisted Continuous Periodic Arbitrary Millimeter Waveform Generation via Direct Space-to-Time Pulse Shaping," *J. D. McKinney*, D. S. Seo, and A. M. Weiner, Conference on Lasers and Electro-optics, Baltimore, MD, June 2-6, 2003.

"Photonically-assisted Arbitrary Millimeter Waveform Generation," *J.D. McKinney*, D.S. Seo*, S. Xiao, and A.M. Weiner, IEEE LEOS Summer Topical Meetings, Vancouver, B.C., July 14-16, 2003.

"GHz Waveform Generation via Direct Space-to-Time Optical Pulse Shaping and Dispersive Stretching," *J.D. McKinney* and A.M. Weiner, IEEE LEOS Summer Topical Meetings, Vancouver, B.C., July 14-16, 2003.

"Multiple Output Channel High Repetition Rate Femtosecond Direct Space-to-Time Pulse Shaping in an Integrated Optic Configuration," *D.E. Leaird* and A.M. Weiner, 16th Annual Meeting of the IEEE Lasers and Electro-Optics Society, Tucson, AZ, Oct. 27-30, 2003.

"Generation of a 500 GHz optical pulse train by repetition-rate multiplication using an arrayed waveguide grating," *D.S. Seo*, D.E. Leaird, A.M. Weiner, S. Kamei, M. Ishii, A. Sugita, and K. Okamoto, 16th Annual Meeting of the IEEE Lasers and Electro-Optics Society, Tucson, AZ, Oct. 27-30, 2003.

"Temporal response of an excitation engineering 1X16 splitter," *D.E. Leaird*, A.M. Weiner, T. Saida, A. Sugita, and K. Okamoto, 16th Annual Meeting of the IEEE Lasers and Electro-Optics Society, Tucson, AZ, Oct. 27-30, 2003.

"Ultrafast Optics Techniques for Microwave – Millimeter Wave Arbitrary Waveform Generation," [**INVITED**] A.M. Weiner, J.D. McKinney, D.E. Leaird, I. Lin, D.S. Seo, F.S. Toong, and S. Xiao, 16th Annual Meeting of the IEEE Lasers and Electro-Optics Society, Tucson, AZ, Oct. 27-30, 2003.

6(c) Papers presented at meetings without conference proceedings

"Ultrafast Pulse Shaping and Selected Applications in Linear and Nonlinear Photonics," **[INVITED]** *A.M. Weiner*, Ultrafast Nonlinear Optics and Semiconductor Lasers, University College Cork, Cork, Ireland, Sept. 5-8, 2001.

"Pulse Shaping Control of Second Order Nonlinear Processes," [**INVITED**] *A. M. Weiner*, 2nd International Conference on Optimal Control of Quantum Dynamics, Ringberg Castle, Tegernsee, Germany, December 9-12, 2001.

"Femtosecond Pulse Processing and Applications to Optical Communications," [**INVITED**] *A. M. Weiner*, First NTT International Meeting on New Frontiers for Ubiquitous IT Services, Atsugi, Japan, May 26-27, 2003.

"Ultrafast Optical Signal Processing: A Parallel Processing Approach," [**INVITED**] *A. M. Weiner*, Europe-U.S.-Japan Symposium on Ultrafast Photonic Technology, Makuhari, Japan, July 15, 2003.

Seminars:

- Spectra Diode Laboratories, San Jose, CA, Dec. 12, 2000

- NTT Photonics Research Laboratories, Ibaraki, Japan, July 19, 2001
- UCLA, Los Angeles, CA, Jan. 10, 2002
- Tektronix, Beaverton, OR, Jan. 11, 2002
- Johns Hopkins University, Baltimore, MD, Feb. 6, 2002
- Purdue University, Center for Education and Research in Information Assurance and Security (CERIAS), West Lafayette, IN, April 24, 2002
- Intel Corp., Hillsboro, OR, Oct. 2, 2002
- Ohio State University, Colombus, OH, Jan. 9, 2003.
- Agilent Laboratories, Palo Alto, CA, Jan. 28, 2003.
- Purdue-ECE Silicon Valley Forum, Santa Clara, CA, April 28, 2003.

6(d) Manuscripts submitted but not published during reporting period

None

6(e) Technical reports submitted to ARO

None

6(f) Additional item: book published

Ultrafast Phenomena XIII, Proceedings of the 13th International Conference, R. D. Miller, M. M. Murnane, N. F. Scherer, and A. M. Weiner, eds. (Berlin: Springer, 2002), 699 pages.

7. Scientific personnel, degrees granted, and awards

7(a) Scientific personnel

- A.M. Weiner (principal investigator/ Professor)
- D.E. Leaird (research engineer/ graduate student).
- J. D. McKinney (visiting assistant professor/ graduate student)
- Dongsun Seo (visiting professor, on leave from Myongi University, South Korea)
- Jung-Ho Chung (graduate student)
- Bhaskaran Muralidharan (graduate student)
- Ryan D. Nelson (graduate student)

7(b) Degrees granted

- D.E. Leaird (Ph.D., December, 2000)
- J. D. McKinney (Ph.D., May 2003)
- Jung-Ho Chung (M.S., May 2001)
- Bhaskaran Muralidharan (M.S., May 2003)
- Ryan D. Nelson (M.S., May 2003)

7(c) Awards received

- A.M. Weiner was named Scifres Distinguished Professor of Electrical and Computer Engineering at Purdue University (2002).

- A.M. Weiner was selected as the inaugural recipient of the Award of Excellence in Research from across the Purdue University Schools of Engineering (2003).

- J.D. McKinney was selected as a finalist for the Optical Society of America New Focus Student Prize (2002).

- J.D. McKinney was selected for the Motorola Prize, given annually to one outstanding Ph.D. student in Purdue Electrical and Computer Engineering (2003).

- J.D. McKinney was selected for the Chorafas Foundation Prize, given annually to one outstanding Ph.D. student at Purdue University (2003).

- Jung-Ho Chung was selected for an IEEE LEOS Graduate Student Fellowship (2003).

8. Report of Inventions

"Direct Space-to-Time Pulse Shaper and Optical Pulse Train Generator" filed with the U.S. Patent Office, Sept. 22, 2000; issued June 10, 2003, as U.S. patent #6,577,782.

"Methods and Apparatus for Generating a Radiation Pulse Sequence," U.S. patent filed July 2, 2002. (previously filed as a provisional patent, July 18, 2001, with title "Optical Pulse Sequence Generation in a Low Loss Configuration).